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Is the Stresst'er a Reliable Stress Test to Detect Mild to Moderate Peripheral Arterial Disease?

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Background. *A stress test is required in patients with a resting ankle brachial pressure index (ABPI) of >0.9 in whom peripheral arterial disease (PAD) is suspected.*
Objective. *To see if the Stresst'er Ergometer could mimic a standard 1 min treadmill exercise test and successfully diagnose the presence of significant PAD.*
Methods. *Legs with a resting ABPI >0.9, a positive exercise test and PAD confirmed on Duplex ultrasound, underwent various protocols on the Stresst'er Ergometer. The results were compared to control legs with no PAD (normal stress test).*
Results. *By making various adjustments to the rate and duration of the exercise, the resistance provided by the Stresst'er to the exercise and the timing of the post exercise ABPI measurement it was possible to accurately diagnose significant PAD.*
Conclusion. *Using an appropriate protocol it is possible to use the Stresst'er Ergometer to assist in the diagnosis of significant PAD. Being a portable, space saving device, the Stresst'er offers the opportunity of diagnosis outside the vascular laboratory. This would facilitate medical therapy to at risk patients.*

Key Words: Peripheral arterial disease; Stresst'er Ergometer; Stress test; Ankle brachial pressure index; Treadmill test.

Introduction

The ankle-brachial pressure index (ABPI) reliably detects peripheral arterial disease (PAD) if the ABPI is <0.9.[1] A stress test of some type is required for accurate and reliable diagnosis in patients with symptoms suggestive of intermittent claudication and a resting ABPI >0.9.[2] Such patients are usually diagnosed in a vascular laboratory with a standard exercise test, such as that described by Laing and Greenhalgh.[3] In this test the patient walks on a treadmill for 1 min at a 10% slope at 4 kmph and the post exercise pressure is measured 40 s later. This test has been shown to be successful in diagnosing significant PAD, recognised by an absolute pressure fall of >30 mmHg. The question is whether the Stresst'er Ergometer can mimic the 1 min exercise test and offer a simpler but reliable diagnosis.

The Stresst'er Ergometer has been developed as a portable, space saving instrument that can be fixed to an examination couch and utilised outside the vascular laboratory setting. Half the population suffering from intermittent claudication think that it is a natural part of the aging process and fail to seek medical help.[4] The presence of PAD is a marker of potentially more important arterial disease elsewhere such as in the coronary and carotid systems.[5] If shown to be successful in the detection of early PAD the Stresst'er could be of value in the community by permitting appropriate medical intervention.[6] Previous experience with the device aimed at evaluating the extent of leg exercise.[7] This study differed in that criteria were sought to recognise significant PAD.

Methods

The Stresst'er Ergometer consists of an upright foot pedal, attached to a horizontal cylinder, which is connected to an adjustable metal plate allowing it to be fixed to an examination couch (Fig. 1). The leg is kept flexed and supported by a cushion behind the knee. The electronic metronome on the top of the cylinder beeps to signal the rate for the patient to plantar-flex the foot. The cylinder spring provides resistance to oppose this action. At the end of plantar-flexion the foot returns to the upright position awaiting the next signal to repeat the exercise.

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Fig. 1. The Stresst'er Ergometer. The foot rests in the foot-plate. The metronome sits on top of the cylinder within which is the spring that provides resistance when the foot plantarflexes. The posterior tibial pulse has been located and marked, a standard pressure cuff is in place and, with the use of Doppler sonography, the resting pressure of the posterior tibial artery has been measured.

The total work done by the leg being tested can be adjusted in three ways, by changing:

1. the number of foot depressions per minute (rpm), by adjusting the metronome
2. the length of the exercise by adjusting the electronic alarm to signal the end of the test
3. the resistance to planterflexion provided by the cylinder (measured in kilogram load) by adjusting the internal spring.

Various combinations of these factors were tested to find if a protocol could be determined to produce a similar post exercise pressure change at the ankle as the 1 min treadmill test.

In the first instance two sets of legs were identified: a group of five legs without PAD (ABPI's >0.9 and negative stress test) compared with a group with five legs with known mild PAD (ABPI > 0.9, but treadmill positive response and disease confirmed by duplex scanning). A series of experiments was performed to see whether the change in post exercise ankle pressure, achieved by each leg during the 1 min treadmill exercise test, could be reproduced by the Stresst'er Ergometer. A larger number of legs, nine with similarly proven mild PAD and nine without PAD, was then used to prospectively test the derived protocol.

Rate of foot depressions (rpm)

Keeping a constant load (4 kg) and exercise time (2 min) the foot flap rate (rpm) was varied. Increasing the number of foot flaps per minute increased the drop in the post exercise ankle blood pressure. The maximum rate with good patient compliance was found to be 75-foot flaps per minute, however, this at the 4 kg load did not provoke the desired pressure fall. Therefore we settled on a rate of 75 rpm as the near maximum tolerated rate that was reproducible.

Length of exercise

At the optimal rate of 75 rpm and at fixed load (4 kg) the exercise test length was varied. Doubling the test time from 1 to 2 min did not increase the pressure fall in legs with Doppler proven PAD. We therefore settled for 1 min of exercise. We had still not produced a post exercise pressure fall comparable to that achieved by the 1 min treadmill test. We therefore attempted to achieve this by varying the timing of the post exercise pressure reading and changing the spring tightness (load) to affect total work done.

Timing of post exercise pressure reading

The 1 min treadmill test was devised with the post exercise pressure being measured at 40 s after the cessation of treadmill walking. This allowed time for the subject to get off the treadmill and onto the couch. A fall of 30 mmHg at this time interval was found to be consistent with the presence of PAD. The option of reading the post exercise ankle pressure earlier, at 15 s was possible using the Stresst'er as the patient was already on the couch with the cuff applied. As we increased the Stresst'er load from the initial 4 kg, we found that, in patients with no PAD, measuring the post Stresst'er ankle pressure at 15 s greatly exaggerated the pressure fall compared to that achieved by the treadmill. Thus, the distinction between diseased and non-diseased legs became unclear. Delaying the ankle pressure measurement post Stresst'er exercise to 40 s caused the pressure falls to more closely resemble those seen using the 1 min exercise test. We therefore opted to record the ankle pressure change at 40 s.

Altering the resistance against foot flexion (load change)

We had now fixed a protocol of 75 rpm for 1 min, with measurement of the post exercise pressure fall at 40 s. The load was increased incrementally from 4 to 10 kg to see if a threshold for pressure fall could be found similar to that seen after the 1 min treadmill test. All patients were able to complete the test on all load settings. Increasing the load produced a greater pressure fall for

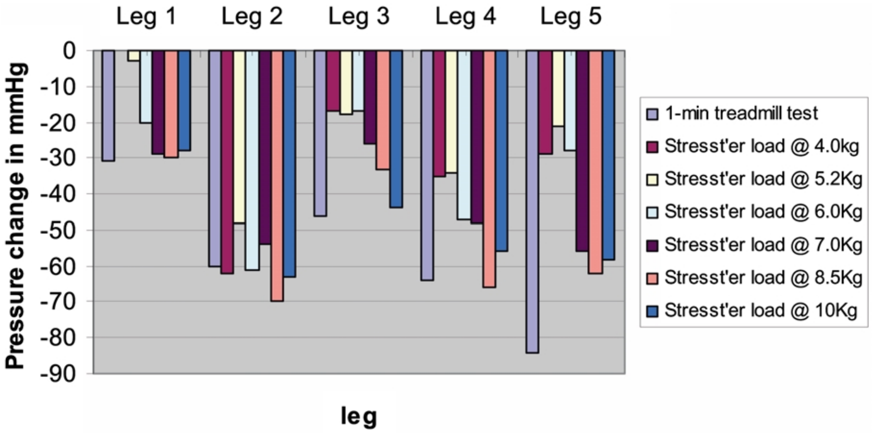

Fig. 2. The bar chart shows results for five legs with proven peripheral arterial disease. The Stresst'er protocol was 1 min exercise and 75-foot flaps per minute ankle pressure measures 40 s post exercise. The Stresst'er load was varied. Increasing the load produced a pressure change that most closely resembled that achieved by the 1 min treadmill test.

the five patients with PAD (Fig. 2). The 8.5 kg load produced the required threshold, provoking a post Stresst'er fall of >30 mmHg in each case. Increasing the load to 10 kg produced no increased response.

Prospective study

We applied the derived protocol (1 min at 75 rpm, 8.5 kg load, 40 s measurement) to nine legs with and nine legs without PAD (Fig. 3). There was good agreement between the 1 min treadmill test and the Stresst'er test for both groups. In all cases a fall of >30 mmHg on the treadmill was matched by a fall of >30 mmHg by the Stresst'er. Similarly, in all cases a fall of <30 mmHg on the treadmill was matched by a fall of <30 mmHg by the Stresst'er. The protocol was thus validated.

To assess test–retest repeatability the same observer repeated the test on each leg after a 15 min interval. A Bland Altman plot showed disease free patients to have inter-reading variability of up to 10 mmHg. In the diagnostic range reading, however, variability was smaller and acceptable, in the region of 5 mmHg.

Discussion

This study was based on a small number of patients, with 10 being used to develop the protocol and 18 for

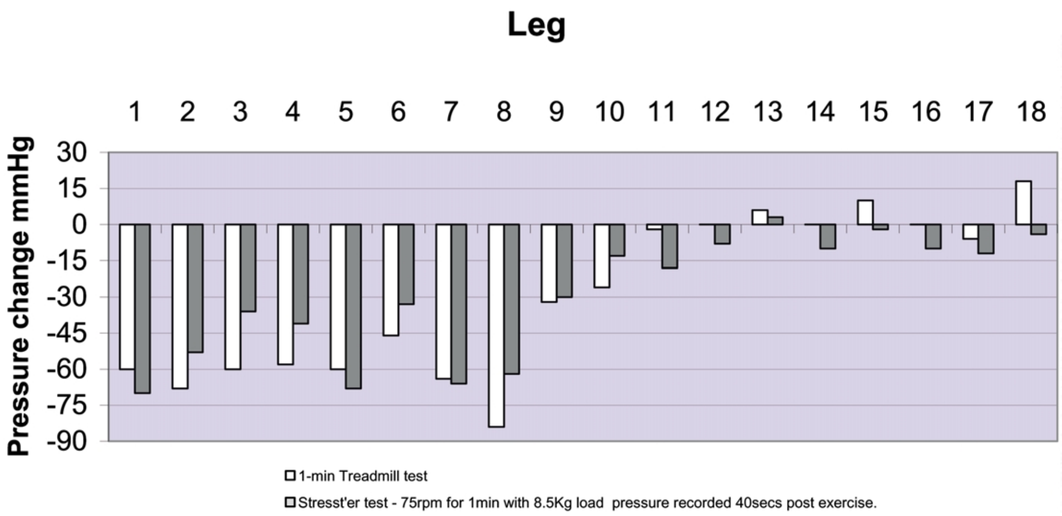

Fig. 3. The bar chart shows results for nine legs with PAD (1–9) and hence a >30 mmHg fall on the 1 min treadmill test, and for nine legs without PAD (10–18) and a fall <30 mmHg on the 1 min treadmill test. In all cases a fall of >30 mmHg on the treadmill was matched by a fall of >30 mmHg by the Stresst'er. Similarly in all cases a fall of <30 mmHg on the treadmill was matched by a fall of <30 mmHg by the Stresst'er. Thus the work done with the Stresst'er protocol (75 foot flaps/min, for 1 min, against 8.5 kg load) is similar to that done in the 1 min treadmill stress test.

validation. However, we have confirmed that a threshold of work done exists to produce an ankle pressure fall after exercise. By setting a rate, duration and fixed post exercise measurement time we have altered the load and found that threshold for the Stresst'er. This work also supports the concept by Laing and Greenhalgh that once a certain threshold of energy has been expended a maximum pressure fall occurs. This fall is remarkably constant and does not increase with further provocation. Using the protocol described we are therefore able to conclude that the Stresst'er can be used in the community to detect significant PAD. The Stresst'er also helps to exclude alternative diagnoses such as sciatica, rather than measuring the disease severity as suggested by Cameron.[7]

The major significance of the early detection of PAD is that, as a marker for multi-system arterial disease, it opens up vital treatment options. The mortality of claudicants is up to four times that of the non-claudicant age adjusted population.[8] Approximately 55% of claudicants will die from heart disease, 10% from a stroke and 10% from abdominal vascular pathology.[9] Indeed less than 20% of claudicants die from a non-vascular cause. Significantly, an asymptomatic patient with PAD has the same risk of cardiovascular events and death as claudicants.[10] Even a slightly reduced ABPI of 0.9 has a two-fold relative risk of a coronary event. It is not so much whether PAD is symptomatic but whether early PAD is present which is vital in terms of risk-factor modification.

Referring all patients over 50 years of age to a vascular clinic for screening would require a huge increase in vascular laboratory staff and equipment. Furthermore as the prevalence of intermittent claudication is known to increase with age, screening would have to be repeated at reasonable age intervals.[11] ABPI measurement where a ratio of <0.9 confirms the presence of PAD will miss a percentage of patients with mild to moderate disease for whom a stress test is known to be required.

We suggest that the Stresst'er, with a suitable protocol, could be useful in the simple, reliable detection of significant PAD, even when asymptomatic. This might aid screening of an at-risk population, with the aim of risk factor modification.

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